BULLETIN

OF THE INSTITUTE OF METALS

VOLUME 3 OCTOBER 1956 PART 14

INSTITUTE NEWS

Election of Members

The following 7 Overseas Sustaining Members, 32 Ordinary Members, 4 Junior Members, and 9 Student Members were elected on 24 August 1956:

As Overseas Sustaining Members

AKTIENGESELLSCHAFT OEDERLIN & CIE., Baden, Switzerland.

L'ALUMINIUM FRANÇAIS, 23 rue Balzac, Paris (8e), France.

ATOMIC ENERGY OF CANADA, LTD., Chalk River, Ont., Canada.

AVRO AIRCRAFT, LTD., Box 4004, Terminal "A", Toronto, Ont., Canada.

BROKEN HILL PROPRIETARY COMPANY, LTD., 422 Little Collins Street, Melbourne, Vic., Australia.

ELECTROLYTIC REFINING AND SMELTING COMPANY OF AUSTRALIA PROPRIETARY, LTD., THE, Collins House, 360 Collins Street, Melbourne, Vic., Australia.

ELECTROLYTIC ZINC COMPANY OF AUSTRALASIA, LTD., P.O. Box 856-K, Melbourne C.1, Australia.

As Ordinary Members

BOVET, Henri Jean, Ing. chim., Dr.-ès-Sc., Assistant Chief of Laboratory, Swiss Metal Works Selve and Co., Thun, Switzerland.

BROWN, John Richard, B.A., Head of the Metal Physics Section, G.K.N. Group Research Laboratory, Birmingham New Road, Lanesfield, Wolverhampton.

CARTWRIGHT, Arthur Eric, Chief Metallurgist, Crane, Ltd., Montreal, P.Q., Canada.

COXE, Charles D., B.S., Chief Metallurgist, Handy and Harman, Bridgeport 1, Conn., U.S.A.

DENSEM, Charles Edward, B.Sc.Tech., Senior Experimental Officer, Royal Naval Scientific Service, Services Electronics Research Laboratories, Baldock, Herts.

GRISON, Emmanuel, Dr-ès-Sc., Chef du Service de Radio-Métallurgie, Département de Métallurgie et de Chimie Appliquée, Commissariat à l'Energie Atomique, Centre d'Etudes Nucléaires de Saclay, Gif-sur-Yvette (S. et O.), France.

GROOTENHUIS, Peter, B.Sc., D.I.C., A.C.G.I., A.M.I.Mech.E., A.F.R.Ae.S., Lecturer, Mechanical Engineering Department, Imperial College of Science and Technology, London, S.W.7.

HAUTMAN, Henry Walter, B.Sc., A.M.I.Mech.E., Technical Director, Pearson Panke, Ltd., 1–3 Hale Grove Gardens, London, N.W.7.

HURST, Alvin Lee, B.S., Works Chief Metallurgist, Aluminum Company of America, P.O. Box 500, Lafayette, Ind., U.S.A.

LOHSE, Robert M., B.S., Metallurgist, Universal-Cyclops Steel Corp., Caldwell Street, Titusville, Pa., U.S.A.

LOUYOT, Gérard-Marie-Pierre, Ing., 79 rue St. Lazare, L'Isle Adam (S. et O.), France.

MOHR, Frederick J., B.S., Senior Metallurgist, Kaiser Aluminum and Chemical Corp., Box 1600, Chalmette, La., U.S.A.

MUNDELL, James Joseph, S.I.Mech.E., Director, Knowsley Cast Metal Co., Ltd., Titan Works, Trafford Park, Manchester 17.

PARRY, Sidney J. S., B.S., Assistant Metallurgist, Metals Department, Armour Research Foundation, Illinois Institute of Technology, Technology Centre, 10 West 35th Street, Chicago 16, Ill., U.S.A.

PERRY, Ralph Donald, B.A., B.Sc., Vice-President and General Manager, The Consolidated Mining and Smelting Company of Canada, Ltd., Trail, B.C., Canada.

ROHR, Robert J., LL.B., M.S., Ph.D., Directeur, Ipsen International, Weteringschans 151, Amsterdam-C, Netherlands.

ROWE, W. Cecil, Foundry Foreman, Crane, Ltd., P.O. Box 189, Calgary, Alberta, Canada.

RYGE, Gunnar, D.D.S., Associate Professor, Department of Dental Materials, Co-ordinator of Research, School of Dentistry, Marquette University, 604 North 16th Street, Milwaukee 3, Wis., U.S.A.

SALESSE, Marc, Chef du Département de Métallurgie et de Chimie Appliquée, Commissariat à l'Energie Atomique, Centre d'Etudes Nucléaires de Saclay, Gif-sur-Yvette (S. et O.), France.

SCHIER, Pavel Omar, Ing., Director, Laboratoř pro Výzkum Materiálu, Československá Akademie Věd, Karlovo nám. 13, Praha II, Czechoslovakia.

SIGWALT, Madeleine, Ingénieur, Société l'Aluminium Français, et Secrétaire, Centre International de Développement de l'Aluminium, 23 rue Balzac, Paris (8e), France.

SPENCER, James M., B.Eng., Project Engineer, Noranda Copper and Brass, Ltd., P.O. Box 1238, Place d'Armes, Montreal, P.Q., Canada.

STANSBURY, *Professor* E. E., B.Ch.E., M.S., Ph.D., Professor of Metallurgical Engineering, Metallurgy Division, Department of Chemical Engineering, University of Tennessee, Knoxville, Tenn., U.S.A.

STRYKER, Robert S., B.S., Metallurgist, Electric Furnace Department, Universal-Cyclops Steel Corp., Bridgeville, Pa., U.S.A.

THOMPSON, John Ward, A.S.T.C.(Met.), M.A.I.M.E., Technical Superintendent, Australian Iron and Steel, Ltd., Port Kembla, N.S.W., Australia.

THOMSON, John, M.A., D.Sc., F.Inst.P., M.I.E.E., Director of Research and Secretary, British Scientific Instrument Research Association, "Sira", South Hill, Chislehurst, Kent.

VACHON, Maurice A., Chief Process Metallurgist, Noranda Copper and Brass, Ltd., P.O. Box 1238, Place d'Armes, Montreal, P.Q., Canada.

WAHLSTEEN, Axel Olof, Vice Managing-Director, A. B. Bofors, Bofors, Sweden.

WALTERS, Archibald Francis, M.B.E., M.I.Mech.E., M.I.Loco.E., Mechanical Engineer, 120–122 Victoria Street, London, S.W.1.

WEBB, Leslie Alfred, Deputy Master, The Royal Mint, 280 William Street, Melbourne, C.1, Vic., Australia.

WILCOX, Virginia Lee, A.B., M.A., Acting Librarian, Colorado School of Mines, Golden, Colo., U.S.A.

ZÜRRER, Theophil, Ing., Dr.-ès-Sc., Chief of the Laboratory, Swiss Metal Works Selve and Co., Thun, Switzerland.

As Junior Members

CARSON, Robert Orrin, Supervisor, Materials Development Laboratory, Orenda Engines, Ltd., Malton, Ont., Canada.

JARMAN, Raymond Arthur, L.I.M., Assistant Experimental Officer, Ministry of Supply, Royal Ordnance Factory 1, Woolwich.

LEE, Ernest Arthur Redvers, B.Sc., Metallurgist, The Plessey Co., Ltd., Ilford, Essex.

TRACEY, Victor Allen, B.Sc., Senior Research Metallurgist, B.S.A. Group Research Centre, Small Heath, Birmingham.

As Student Members

ATKINSON, Harry Hindmarsh, M.Sc., Research Student, Crystallographic Laboratory, Cavendish Laboratory, Cambridge.

BARRAND, Peter, Undergraduate, Department of Metallurgy, University of Manchester.

CHAKRABORTY, Amiya Kumar, B.Sc., c/o Fulmer Research Institute, Stoke Poges, Bucks.

HARRISON, K. A., Student, College of Technology, Birmingham; Laboratory Assistant, Joseph Lucas, Ltd., Great King Street, Birmingham.

O'HARA, Michael J., Undergraduate, Department of Metallurgy, University College, Cardiff.

PRICE, Christopher Eric, Undergraduate, Department of Metallurgy, University College, Swansea.

REDSTONE, Seymour Ivor, Undergraduate, University of Cambridge.

SUTTON, Kenneth Victor, Imperial Chemical Industries, Ltd., Metals Division, Kynoch Works, Witton, Birmingham 6.

WHITE, Frederick Ernest, Undergraduate, University of Cambridge.

PERSONAL NOTES

MR. K. BENNETT has left The Chloride Electrical Storage Co., Ltd., to join the Technical Department of Frederick Smith and Co., Ltd., Manchester.

MR. D. C. BONE has been awarded the B.Sc., A.R.S.M. degrees of London University and is now on the staff of Aluminium Laboratories, Ltd., Banbury.

MR. G. T. BROWN has left Linread, Ltd., and joined the staff of the G.K.N. Group Research Laboratories, Wolverhampton.

MR. E. H. BUCKNALL, who recently relinquished the post of Director of the National Metallurgical Laboratory, India, has been appointed Visiting Professor of Metallurgical Engineering in the University of Texas, Austin, Texas, U.S.A.

MR. G. A. DUMMETT has been elected to the Board of Directors of The A.P.V. Co., Ltd., Crawley. He joined the Company in 1935 and has been successively Laboratory Manager and Scientific Manager responsible for the Research and Development Organization of the Company.

MR. B. S. EKELUND has left Stora Kopparberg Bergslags Aktiebolag, Falun, Sweden, to take charge of the Metals Research Section of the Bjorksten Research Laboratories, Madison, Wis., U.S.A.

DR. W. L. FINK, Chief of the Physical Metallurgy Division, Aluminum Research Laboratories, New Kensington, Pa., was one of eleven persons to receive an Award of Merit of the American Society for Testing Materials at a recent meeting of the Society.

MR. FRANK W. GLASER, Executive Vice-President and General Manager of Alloy Precision Castings Co., Cleveland, Ohio, has been appointed a Director of Mercast (Great Britain), Ltd., London.

DR. B. W. GONSER, Assistant Director, Battelle Memorial Institute, Columbus, Ohio, has received an Award of Merit from the American Society for Testing Materials.

MR. P. B. HIGGINS has joined the board of Jonas Woodhead and Sons, Ltd.

DR. J. E. HILLIARD has left the Massachusetts Institute of Technology to take up an appointment in the General Electric Research Laboratory, Schenectady, N.Y.

MR. E. J. HOOKER has been awarded the Ph.D. degree of London University.

DR. ZAY JEFFRIES has been appointed Director-General of the Second World Metallurgical Congress to be held in Chicago, Ill., on 2–8 November 1957. He served in a similar capacity for the First Congress, held in Detroit, Mich., in 1951.

MR. B. J. MEADOWS has been awarded the B.Sc. degree in Engineering (Metallurgy) with first-class honours of the University of London. He has also been elected an Associate of the College of Technology, Birmingham.

MR. JACK MORGAN, Foundry Services (Canada), Ltd., has recently been appointed a director of the Ontario Chapter of the American Foundrymen's Society for a term of three years.

DR. E. G. RAMACHANDRAN has been appointed Assistant Director of the National Metallurgical Laboratory, Jamshedpur, India.

MR. A. G. E. ROBIETTE, of John Miles and Partners (London), Ltd., has been awarded the degree of D.Sc. of the University of Wales.

MR. R. A. SCHATZEL, Vice-President and Director of Engineering, Rome Cable Corporation, Rome, N.Y., has been elected President of the American Society for Testing Materials for the year 1956–57.

MR. H. W. WEART has left the University of Wisconsin, where he has obtained the degree of Ph.D. (Metallurgical Engineering), and is now a research engineer in the Research Laboratories of the Westinghouse Electric Corporation, Pittsburgh, Pa.

MR. R. D. WEBER has left Enfield Rolling Mills, Ltd., to take up a post as Production Engineer with A. B. Svenska Metallwerken, Västerås, Sweden.

MR. H. WINNING is now General Manager of the Glass Laminate Division, Tenaplas, Ltd., Pangbourne, Berks.

MR. J. G. WISTREICH has been appointed Head of the Mechanical Working Division of the British Iron and Steel Research Association. He was previously Head of the Metal Working Laboratory of the Association at Sheffield.

OBITUARY

M. Albert Féron

M. Albert Féron, an Original Member of the Institute, died in Brussels on 2 July, aged 82.

Trained as an electrical engineer at the University of Liège and the Institut Montefiore, M. Féron founded in 1903 the

Société Anonyme Visseries et Tréfileries Réunies, at Haren, for the manufacture principally of wood screws, in iron and brass, and other items of ironmongery.

From 1908 onwards, M. Féron interested himself in a project for producing brass wire instead of importing it. A scheme was approved by the Board of the Company in 1912, and the necessary plant was all installed and ready to go into production in August 1914 when war broke out. The firm's buildings were requisitioned and the equipment carried off to Germany. A large part of it was eventually recovered after the war, but it was not until 1922 that the brass works finally began operation. It has since been greatly expanded and now employs 1000 workmen, producing not only wire, but also sheet, strip, rod, and tube in copper and brass.

The screw works also extended its range of products and in 1932 a branch was established in France—Visseries de Fourmie S.A.R.L.

During the Second World War, the firm's activities were greatly restricted, and because they would not undertake the manufacture of certain products of a military character, M. Féron and his fellow-directors were dismissed by the Germans. Since the war, further steps have been taken to extend the scope of activities and modernize the plant.

At the time of his death, M. Féron was Président and Administrateur-Délégué of S.A. Visseries et Tréfileries Réunies, Président of S.A. Etablissements Vanderborght Frères, and Président honoraire of S.A. Glaces d'Auvelais. He was a Commandeur de l'Ordre de Léopold and an Officier de la Légion d'Honneur.

M. Féron attended a number of meetings of the Institute, which he had actively supported from its foundation. He was also a founder member of the International Conference of Non-Ferrous Metals Manufacturers.

JOINT ACTIVITIES

Beilby Memorial Awards

From the interest derived from the invested capital of the Sir George Beilby Memorial Fund, at intervals to be determined by the Administrators representing the Royal Institute of Chemistry, the Society of Chemical Industry, and the Institute of Metals, awards are made to British investigators in science to mark appreciation of records of distinguished work. Preference is given to investigations relating to the special interests of Sir George Beilby, including problems connected with fuel economy, chemical engineering, and metallurgy. The awards are made, not on the result of any competition, but in recognition of continuous work of exceptional merit bearing evidence of distinct advancement in science and practice.

In general, awards are not applicable to workers of established repute, but are granted as an encouragement to younger men who have done original independent work of exceptional merit over a period of years.

The Administrators are empowered to make more than one award in a given year if work of sufficient merit by several candidates is brought to their notice. For 1956 two awards were made, each of 150 guineas, to Dr. F. D. Richardson and Dr. F. Wormwell.

Consideration will be given to the making of an award or awards from the Fund early in 1957. Outstanding work of the nature indicated may be brought to the notice of the Administrators, either by persons who desire to recommend the candidate or by the candidate himself, not later than 31 December 1956, by letter addressed to The Convener of the Administrators, Sir George Beilby Memorial Fund, The Royal Institute of Chemistry, 30 Russell Square, London, W.C.1.

The letter should be accompanied by nine copies of a short statement on the candidate's career (date of birth, education and experience, degrees and other qualifications, special awards, &c., with dates) and of a list of titles, with references, of papers or other works published by the candidate, independently or jointly. Candidates are also advised to forward one reprint of each published paper of which copies are available.

Informal Discussion

B16 RADIATION DAMAGE TO METALS AND ASSOCIATED PROBLEMS *

IRRADIATION TECHNIQUES FOR FISSILE MATERIALS

By O. S. PLAIL

Introduction

For the past few years investigations have been going on at Harwell into the effects of neutron irradiation on both fissile and non-fissile materials. In general, the more difficult problems of technique are associated with the fissile irradiations, and this paper is concerned mainly with the problems thus encountered. The subject can be dealt with under two main headings. First, there is the sample preparation and actual irradiation (i.e. the exposure of specimens to neutron bombardment) and, secondly, the subsequent examination of the samples when they are themselves highly radioactive.

Irradiation Techniques

The specimens that have been irradiated by the Metallurgy Division, Harwell, have varied in size from wires of natural uranium less than 1 g. in weight to full-size slugs weighing several kilogrammes. Included in these have been prototype fuel elements and samples of highly enriched material.†

In general, the experimenter in this field has the choice of carrying out his work in either (*a*) the standard fuel-element channels in a pile or (*b*) special experimental holes, or " thimbles " as they are sometimes called, incorporated into the pile for experimental use. Theoretically, these special positions should provide conditions under which accurate control—so necessary for metallurgical work—can be maintained. In practice, however, these conditions are difficult and costly to attain. The standard fuel-element positions are useful for experiments of a more general nature, such as testing a batch of fuel elements under actual operating conditions, and this type of experiment is straightforward. It consists of canning the slugs or fuel in containers more or less standard for the particular reactor and loading direct into the normal channels; but the experimenter must be sure that any variation he has made during the manufacture, i.e. altered heat-treatment, will not, as far as he can predict, cause failure of the experimental fuel element. If failure occurred, serious damage might be done to the reactor, and there is already an instance of this happening.

When using the experimental holes, however, the position is quite different. For engineering and nuclear reasons, these " thimbles " are usually fairly small in cross-sectional area, and we have been using holes as small as 1·5 in. dia. In gas-cooled piles, the length of these " thimbles " may be up to 30 ft., so that the experiment will take place at this distance from the nearest access point.

Another factor is that these holes are lined with a tube, and the specimens placed in them do not receive any direct cooling from the pile-coolant stream. This is an important consideration because accurate temperature control is usually essential, and, according to the amount of fissionable material in the specimen, either some external heating or cooling has to be supplied.

Temperature Control

A variety of methods of temperature control are available, but they are dependent on whether heat has to be supplied to the specimens or excess fission heat has to be removed.

In the simplest case, where it is desired to irradiate either a pure metal or a very small quantity of natural uranium in a very low flux, the probability is that heat losses from the specimen container are so great that external heat has to be supplied. A reliable furnace must therefore be used. If the fission heat is increased by enriching the specimens, then it may be necessary to provide some form of cooling to reduce the maximum temperature reached. A great deal of work with samples of this nature has been carried out in the Metallurgy Division at Harwell, and it has been the policy to place the specimen in a sodium-filled container of dimensions such that heat losses from the container surface by convection and radiation bring down the temperature to a point below that desired for control. Further heat is then supplied by a furnace (Fig. 1).

Increasing either the neutron flux or enrichment still further will, of course, increase the heat output until cooling by some fluid is necessary to remove the fission heat and prevent the sample from melting. This increase in heat output has been met by introducing a coolant, the apparatus being designed so that there is a considerable temperature drop from the specimen to the coolant, and by suitable positioning of a furnace temperature control has been achieved without having to vary the coolant flow (Fig. 2).

When, however, the heat output becomes very great, as in the irradiation of a full-scale experimental fuel element, a " loop " has to be used. This consists of a circulating coolant system, of water, gas, or molten metal (e.g. sodium), which is generally in direct contact with the can containing the fuel material, and temperature control is effected by varying this coolant temperature and flow (Fig. 3 (*a*) and (*b*)).

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* Papers forming the basis of an Informal Discussion organized by the Metal Physics Committee of the Institute of Metals and held in connection with the Autumn Meeting at Buxton, on 22 September 1955. The papers were contributed by members of the staff of the Atomic Energy Research Establishment, Harwell, Berks. Four other papers appeared in the August issue of the *Bulletin*.

† Enriched material is material in which the fissile content has been increased above that occurring naturally.

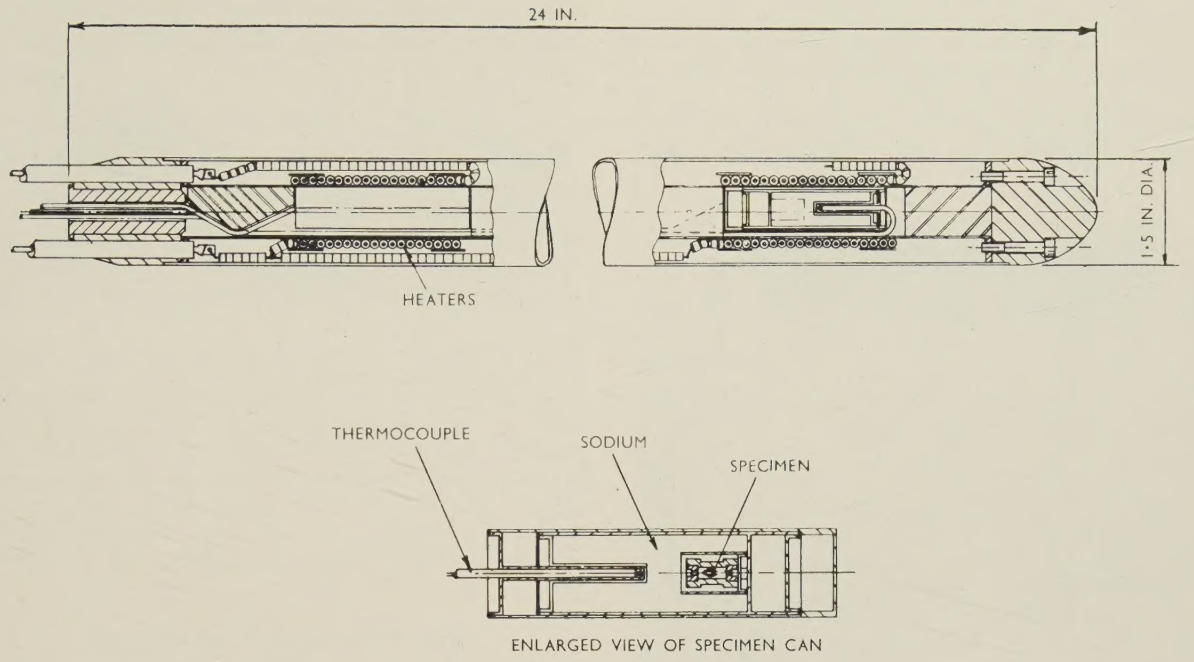


FIG. 1.—Irradiation Assembly Used for Samples with Low Heat Output.

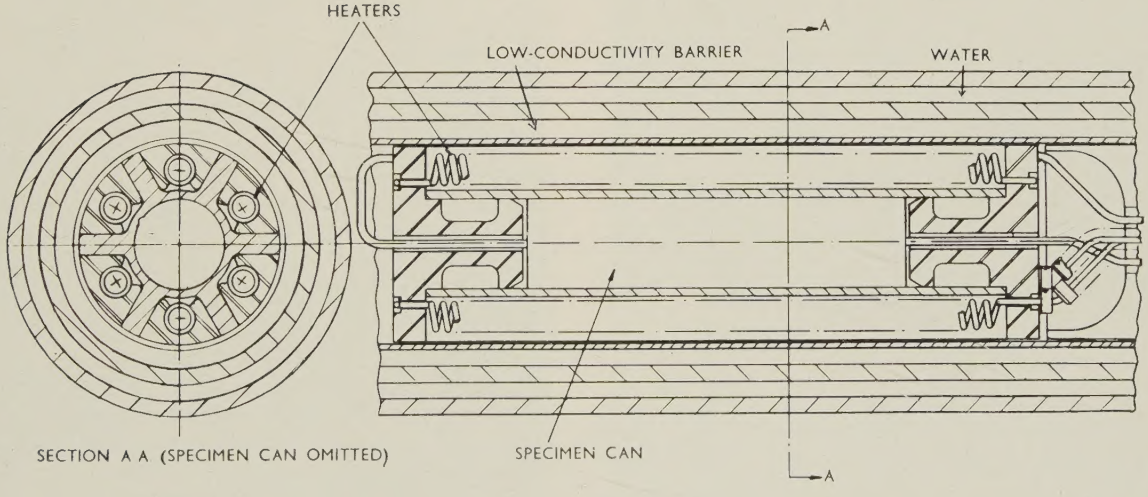
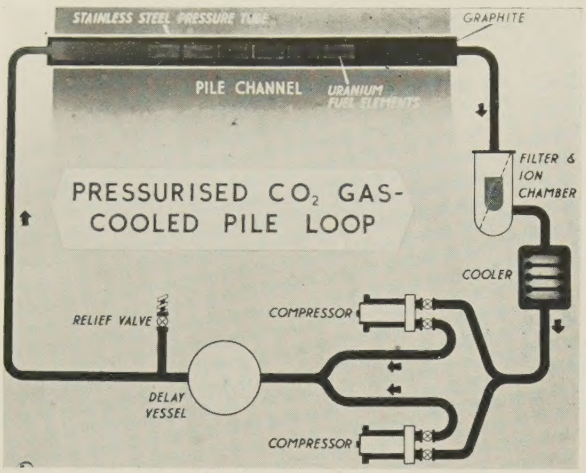
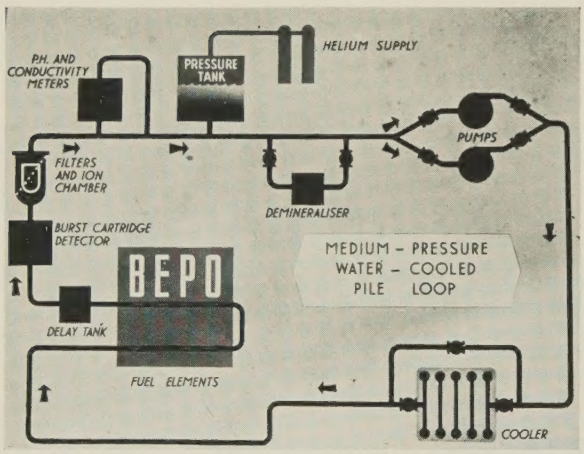


FIG. 2.—Apparatus for Specimens of Higher Heat Outputs.

For all this work, temperature control should be as precise as possible. As an example of this, it is known that both irradiation by itself and thermal cycling through the α–β transformation of uranium can independently cause dimensional changes. It would thus be difficult to interpret any results from a specimen which had undergone thermal cycling consequent upon power fluctuations in the reactor (e.g. shutdowns). Hence the method of temperature control must be capable of compensating for up to 100% loss of fission heat at



(*a*)



(*b*)

FIG. 3.—Typical Layouts of (*a*) a Gas-Cooled Loop, (*b*) a Water-Cooled Loop.

zero reactor power, and must also be able at full reactor power to supply just sufficient heat to maintain the desired control temperature.

Response to temperature fluctuations should also be as rapid as possible. This problem at first gave rise to considerable concern, but has now been solved to a large degree.

Safety

In all this work the design and construction of the apparatus must be such that no breakdown can occur during operation. For instance, can failure results in the release of highly dangerous radioactive fission products; a furnace failure might mean the loss of an expensive experiment as well as delay in obtaining an important result. Moreover, failure in some circumstances might cause damage to the reactor. Therefore a very high standard of manufacturing and pre-irradiation testing is essential.

Materials

Materials should, as far as possible, be chosen so that their neutron absorption is low, but, of course, this has to be related to their suitability in other respects, such as compatibility with molten metals (e.g. sodium) and strength at temperature. Aluminium and magnesium are useful for low-temperature work, but are not compatible with many molten metals such as sodium. Zirconium is limited in application because of its high oxidation rate in air and its low strength at high temperature, but use is being made of it for some rigs. One is forced to use steels and Nimonic alloys for part of the assemblies, but sections are reduced to an absolute minimum compatible with strength. Unfortunately, these types of material have considerable neutron absorption in the pile and, particularly where cobalt is present in more than fractional percentages, very long-lived γ activity. This necessitates considerably thicker shielding for post-irradiation examination than is normally used.

Post-Irradiation Examination

The properties which are of interest to the metallurgist after irradiation of a fissile specimen are obviously those that will indicate any structural changes that may have occurred in the material which could affect its usefulness as a reactor fuel. These include dimensional changes, measurements of density and mechanical properties, and microscopic examinations. Such examinations have to be carried out remotely behind adequate shielding, as the samples are all highly radioactive and dangerous to personnel. Methods of carrying out this work have therefore had to be devised which give adequate health protection, but which do not prevent accurate measurements being made.

Equipment

Basically, the method of carrying out this work is to instal equipment in a working space, surround this with suitable shielding, and supply some form of remote-handling arm or manipulator. The designs of working area, shielding method, and remote-handling gear are very closely interconnected. For instance, if a large deep pit is available and both the equipment to be used and the material that has been irradiated are resistant to water corrosion, then shielding with several feet of water is practicable. The author has made some very useful measurements of surface conditions on uranium bars by this technique. Another method involves the use of lead shielding surrounding a fairly small area, approximately 4 ft. square, and using tongs which pass through the lead wall via a ball joint to operate the equipment inside. Fig. 4 shows such a unit. In this type of equipment, viewing the operations presents some problems, but by the use of windows manufactured from dense leaded glass it has proved possible to operate such boxes successfully. Unfortunately, no glass is available having the same density as lead, so that the windows tend to be somewhat thicker than the surrounding lead shielding walls for equivalent shielding effect, and design difficulties are sometimes experienced on this account. There is another method which has seen much use

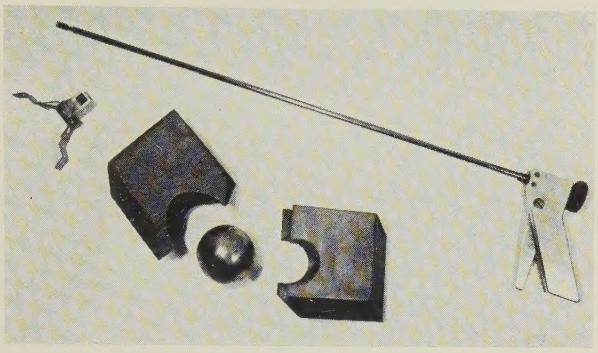
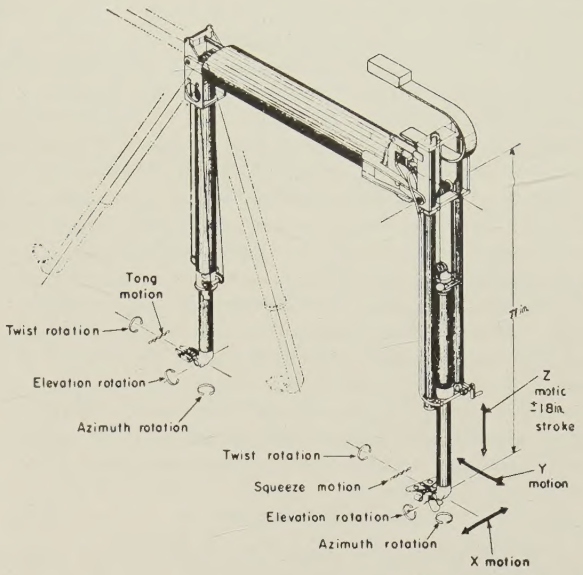


FIG. 4.—Exploded View of Lead Ball Joint Used for Remote Handling.



[*Courtesy "Nucleonics"*

FIG. 5.—Master and Slave Arm. Connecting linkages pass through an 8-in.-dia. tube mounted in horizontal hole 115–120 in. above floor level; rollers in hole provide freedom of rotation about horizontal-tube axis.

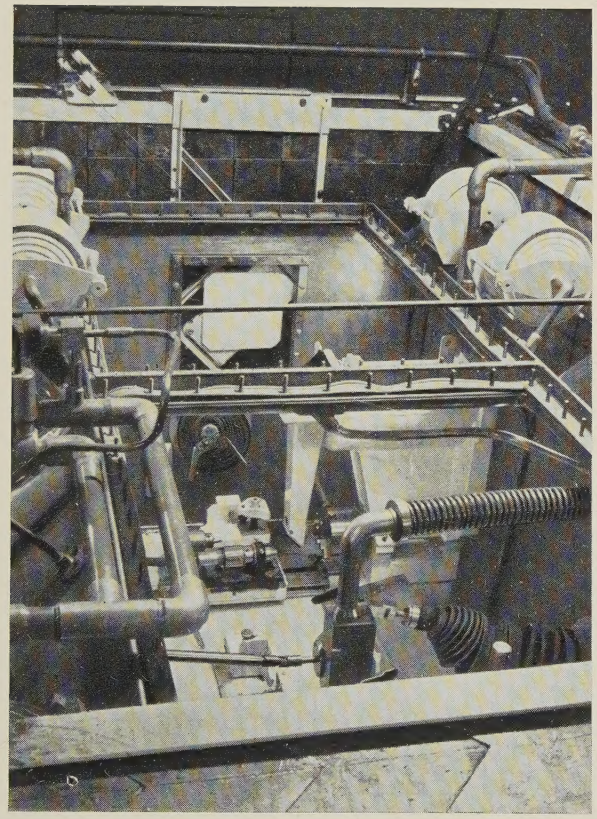


FIG. 6.—Internal View of Lead-Shielded Box with Lathe Used for Welding of Cylindrical Cans.

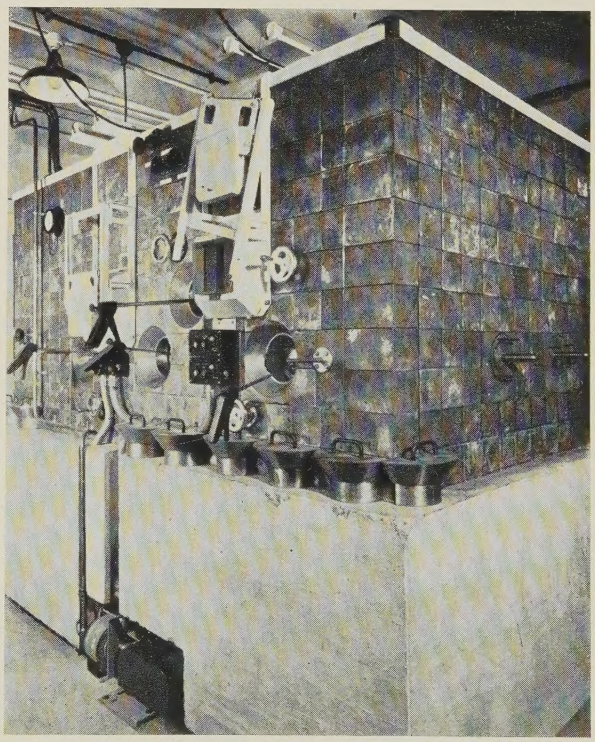


FIG. 7.—External View of Lead-Shielded Box.

in the U.S.A. This consists in shielding a rather larger area with concrete and using "Master and Slave" type mechanical manipulators to operate the equipment (see Fig. 5). This method offers considerable advantages over the other methods available, mainly because of the greater ease and flexibility of manipulation and the higher activity levels which can be accommodated. Viewing through the concrete shielding is carried out either by the use of leaded glass or zinc bromide solution which has the equivalent shielding effect to that of concrete. At Harwell in the past, use has been made of the lead-shielded boxes extensively for work of fairly low activities, but for high-activity-level work concrete cell facilities are being constructed. Figs. 6 and 7 show some of the lead-shielded boxes at present in use. In these boxes it has been possible to carry out work using a standard sensitive balance and making density measurements by displacement of $\frac{1}{2}$-g. samples to an accuracy of $\pm 1\%$, which is just about as high an accuracy as would be expected in normal laboratory work. At the same time mechanical operations such as milling, and argon-arc welding on thin stainless-steel cans, have been carried out.

Conclusion

It will be apparent from the above that both the irradiation proper and the remote handling present their own peculiar problems, and the cost both in time and equipment of carrying out these types of experiment is very high in comparison with normal laboratory practice. The experiments are, however, a vital step in the ultimate economic production of power from atomic energy.

Acknowledgements

The author wishes to acknowledge his indebtedness to colleagues of the Metallurgy and Engineering Divisions at A.E.R.E. in the development of the techniques described in this paper.

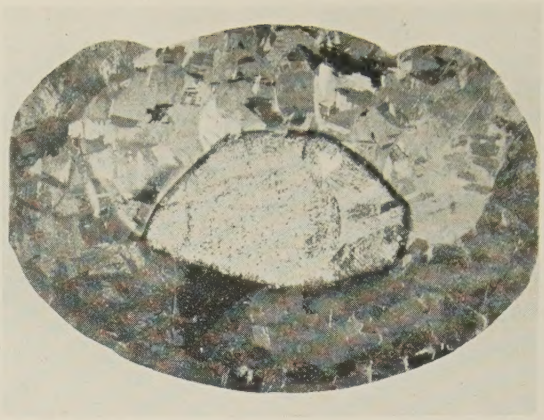


FIG. 1.—Etched Cross-Section of an Inhomogeneous Ingot of a Titanium–Aluminium Alloy (nominally 12 at.-% Al) Produced by Repeated Remelting with Simple Inversion Between Remelts. × 4.

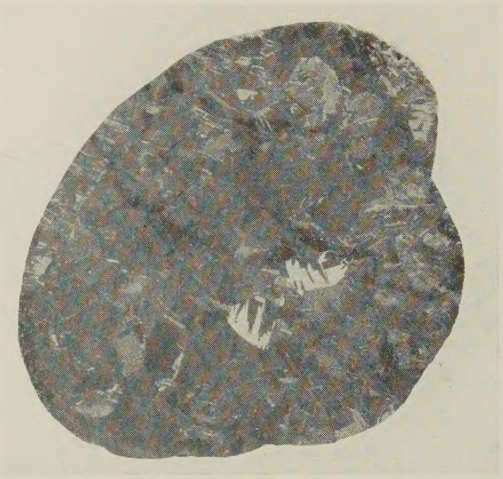


FIG. 2.—Etched Cross-Section of a Homogeneous Ingot Produced by the New Technique. Nominal composition as for Fig. 1. × 4.

LETTER TO THE EDITOR

Preparation of Small, Homogeneous Ingots by Argon-Arc Melting

Different techniques are used to ensure homogeneity in small and large ingots produced by melting in argon-arc furnaces. A titanium alloy ingot weighing 10–20 g. can be homogenized by repeated melting, the ingot being inverted before each remelt. As most of the ingot is molten during the melting operation, small homogeneous ingots are fairly easily obtained. For large ingots, weighing half a pound or more, homogeneity is generally achieved by a double-melting technique in which the second melting operation is carried out with a consumable electrode produced from the first melt.

An alternative technique has been developed to produce homogeneous ingots of titanium alloys, weighing about 80 g., in a laboratory arc furnace. These ingots are suitable for the production of bar and miniature test-pieces.[1]

The copper hearth of the arc furnace contains a trough about $3 \times \frac{1}{2} \times \frac{1}{2}$ in. If the alloying ingredients are melted together in this trough, turned over and remelted, then, because of incomplete melting, a homogeneous ingot is not obtained even after repeating the operation several times (cf. Fig. 1). Homogeneous ingots, as shown by Fig. 2, are easily obtained by employing the process illustrated in Fig. 3. The ingot is

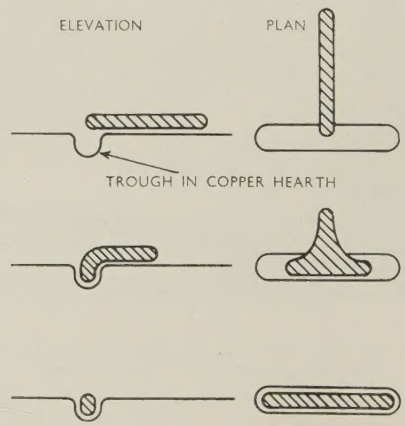


FIG. 3.—Stages in the Production of a Homogeneous Ingot.

placed at right angles to the trough, and molten material is made to run down into the trough under the combined forces of gravity and surface tension. When this process is repeated several times, the thorough mixing ensures that homogeneous ingots are obtained, even though the ingot is not entirely molten at any stage.

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REFERENCES

1. J. W. Suiter, *J. Inst. Metals*, 1954–55, **83**, 460.

OTHER NEWS

The Second International Conference on Non-Destructive Testing

The Second International Conference on Non-Destructive Testing will be held in Chicago, Ill., U.S.A., from 4 to 8 November 1957. This Conference is being arranged in close collaboration with the American Society for Metals, which is organizing the Second World Metallurgical Congress to be held simultaneously. The following tentative programme has been outlined:

(1) Conferees will meet in New York City not later than Saturday, 19 October 1957, provided they are interested in point (2).

(2) Guided tours for two weeks will be scheduled to see important plants, institutions, and operations in the eastern part of U.S.A.

(3) These tours will end in Chicago, Ill., on Saturday, 2 November 1957, to be followed by:

(4) The Second International Conference on Non-Destructive Testing from 4 to 8 November 1957.

The headings of the various sessions will be as follows:

(*a*) The basis for optimum test method selection.

(*b*) The relative advantages and limitations of non-destructive testing.

(*c*) Recommendations for technical development and standardization.

It is intended that this Second International Conference shall be a "participation conference" rather than an "information conference". The Conference language will be English. The papers or abstracts will be submitted in English, French, German, or Spanish, to the Technical Chairman of the Conference, Carlton H. Hastings, Watertown Arsenal, Watertown, Mass., by 1 January 1957 (English preferred). The abstracts will be printed in all languages indicated above and distributed to all conferees by 1 May 1957.

DIARY

Local Sections and Associated Societies

24 October. Liverpool Metallurgical Society. Visit to Meccano, Ltd., Binns Road, Liverpool 13.

24 October. Manchester Metallurgical Society. "Stress Corrosion", by Dr. T. P. Hoar. (Central Library, Manchester, at 6.30 p.m.)

25 October. Birmingham Local Section. "Dry Corrosion", by E. C. Williams. (Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, at 6.30 p.m.)

1 November. Leeds Metallurgical Society. "Powder Metallurgy Applied to Mechanical Parts", by H. Davies. (Large Chemistry Lecture Theatre, The University, Leeds, at 7.15 p.m.)

1 November. London Local Section. "Primitive Metallurgy", by Professor F. C. Thompson. (The Royal School of Mines, Prince Consort Road, S.W.7, at 7.0 p.m.)

6 November. Oxford Local Section. "Radiation Damage", by Dr. A. T. Churchman. (Cadena Café, Cornmarket Street, Oxford, at 7.0 p.m.)

7 November. Manchester Metallurgical Society. "The Properties of Hiduminium 100 (S.A.P.)", by Dr. W. M. Doyle. (Central Library, Manchester, at 6.30 p.m.)

8 November. Birmingham Local Section. "The Metallurgy of Steel for Deep Drawing and Pressing", by A. J. K. Honeyman. (Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, at 6.30 p.m.)

12 November. Scottish Local Section. Visit to British Hydrocarbon Chemicals, Ltd., Grangemouth. (2.30 p.m.)

13 November. South Wales Local Section. "Fuel", by C. A. J. Plummer. (Electricity Showrooms, Kingsway, Swansea, at 6.45 p.m.)

15 November. Liverpool Metallurgical Society. "Some Metallurgical Aspects of Welding Non-Ferrous Metals", by P. T. Houldcroft. (Joint meeting with the Institute of Welding, Liverpool Branch.) (Liverpool Engineering Society, The Temple, Dale Street, Liverpool, at 7.0 p.m.)

19 November. North East Metallurgical Society. "Analytical Control by the Quantometer", by W. S. Sykes. (Cleveland Scientific and Technical Institution, Middlesbrough, at 7.15 p.m.)

APPOINTMENTS VACANT

METALLURGICAL RESEARCH

The Mond Nickel Company, Ltd., invites applications from metallurgists or physical metallurgists to join the Senior Research Staff of its Laboratory at Birmingham, and to carry out investigations, both fundamental and short-term, concerned with the development of new, and the extension of established uses of, non-ferrous materials.

The work will cover a wide field, e.g. the investigation of alloys to resist "dry corrosion" at high temperatures and the development of alloys having special physical properties. Individual publication of results is encouraged.

Applicants should hold a University degree or equivalent in metallurgy or physics.

Salary will be in accordance with experience and qualifications. Pension and insurance schemes are in operation and, in appropriate cases, assistance can be given for housing.

Applications, giving details of age, qualifications, and experience, should be addressed to the Manager, Development and Research Dept., The Mond Nickel Company, Ltd., Thames House, Millbank, London, S.W.1. Mark envelope "Confidential L.33".

METALLURGIST with University degree or equivalent required for investigational work on the welding of non-ferrous metals in metallurgical research department in North London area. Some experience in research or industry desirable; a knowledge of arc welding an advantage but not essential. Excellent salary and prospects for suitable applicant. Write Box 415, The Institute of Metals, 17 Belgrave Square, London, S.W.1.

METALLURGISTS. Applications are invited to fill the following posts:

Junior Powder Metallurgist to assist with experimental work and development of pilot plant.

Junior Metallurgist to assist in control of melting, casting, and processing of non-ferrous alloys.

Candidates should have completed National Service and have some experience in a metallurgical laboratory. Please write fully to Box 416, The Institute of Metals, 17 Belgrave Square, London, S.W.1.

METALLURGISTS. There are vacancies for metallurgists of B.Sc., or L.I.M. standard in the Research Laboratory of the Fairey Aviation Co., Ltd. The work is interesting and includes static and fatigue investigations on new materials and research on heat-treatment. Applications should be made to the Personnel Manager, The Fairey Aviation Company, Ltd., Hayes, Middlesex.

SENIOR METALLURGIST with degree or equivalent standard is required for small laboratory dealing with materials and processes for aircraft construction. Please write giving full details of past experience and degrees held to Box A.C. 22097 Samson Clark, 57–61 Mortimer Street, W.1.

THE COLLEGE OF AERONAUTICS

The Governing Body invites applications for the appointment of PROFESSOR OF MATERIALS AND METALLURGY, from candidates with high academic qualifications and considerable experience in research or development work in metallurgy or generally in the science of materials. This is a new appointment being made for the purpose of stimulating research in metallurgy and related subjects with a view to the special needs, present and future, of aeronautical engineering, and developing the curriculum of the postgraduate Diploma Course in this field. The opportunities for fruitful research in materials and metallurgy in the College are particularly good because of the close association with the advanced work going on in the Departments of Aircraft Design, Propulsion, and Production. The salary will be within the range £1600 to £1950 p.a., with superannuation under F.S.S.U. and family allowance. A modern house will be available for renting if required. Applications should be addressed to the Principal of the College of Aeronautics, Cranfield, Bletchley, Bucks, to reach him not later than 31 October 1956. Further particulars may be obtained from the Recorder at the same address.

UNIVERSITY OF OTAGO
Dunedin, New Zealand

The University proposes to appoint a SENIOR LECTURER IN MINERAL ENGINEERING.

Salary range £1275 × £50 to £1575 p.a.

Further particulars are available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Applications close in New Zealand and London on 31 October 1956.

UNIVERSITY OF THE WITWATERSRAND
Johannesburg, South Africa

Applications are invited for appointment to a post of LECTURER IN PHYSICAL METALLURGY on the staff of the University's Department of Metallurgy.

The salary attached to the post will be on the scale £850 × £50 to £1150 per annum, plus a cost of living allowance at the rate of £234 per annum in the case of a married man.

Membership of the Provident Fund is compulsory and involves a contribution at the rate of 7% of the salary paid. Membership of the Staff Medical Aid Fund is obligatory in the case of an officer who is found eligible for membership.

Applicants are advised to obtain further information regarding this vacancy from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Applications close in South Africa and London on 31 October 1956.

WELDING RESEARCH

A vacancy exists, on the Senior Staff of the Research Laboratory of The Mond Nickel Company, Ltd., Birmingham, for an experienced metallurgist who will be responsible for short- and long-term investigations relating to the welding and brazing of nickel-containing materials. The work involves the application of new and established welding techniques, the study of new materials, and the differing requirements of several European countries. Individual publication of results is encouraged. The applicant should hold a University degree in Metallurgy, or be an Associate of the Institution of Metallurgists, should possess industrial or research experience in the field of welding, and should be capable of working on his own initiative.

Salary will be in accordance with experience and qualifications. Pension and insurance schemes are in operation and, in appropriate cases, assistance can be given for housing.

Applications, giving details of age, qualifications, and experience, should be addressed to the Manager, Development and Research Dept., The Mond Nickel Company, Ltd., Thames House, Millbank, London, S.W.1. Mark envelope "Confidential L.34".

YOUNG GRADUATES are required by the Zinc Development Association as technical officers. The Association has world-wide contacts and offers varied work and opportunities to travel in administering the affairs of affiliated technical associations. Candidates must have a scientific or technical background, with or without industrial experience, and should be able to write well. The posts carry superannuation benefits. Apply to the Director, Zinc Development Association, 34 Berkeley Square, London, W.1.

IMPERIAL SMELTING CORPORATION LIMITED has vacancies in the Development Department for Extraction Metallurgists or Physical Chemists with independence of thought who are prepared to undertake work of a varied nature both on new developments and involving investigations into the efficiency of established processes. Applications are invited from persons with an honours degree in Metallurgy or Chemistry who have completed, or are free from, National Service obligations. Previous industrial experience, although not essential, would be advantageous. Initial applications to Personnel Manager, Imperial Smelting Corp. Ltd., St. Andrew's Road, Avonmouth, Bristol, quoting reference DB/IM.